APPARATUS FOR SEALING A LOAD PLACED ON A PALLET

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a divisional application of United States Patent Application Serial No. 10/115,270, which application claims priority on United States Patent Application Serial No. 09/826,384 and United States Provisional Application for Patent Serial No. 60/367,352.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to the handling of loads placed on pallets. More particularly, the present invention relates to apparatus for sealing a load, such as cartons of goods or produce, placed on a pallet. One useful application of the present invention is the sealing and preservation of produce such as fruits and vegetables within an artificial environment for shipping and storage, where the produce is packed in cartons which are, in turn, stacked on pallets for shipping.

Description of the Related Art

[0003] The movement of produce from the field or orchard to the marketplace is a primary concern for farmers and merchants. To ensure freshness for the consumer, produce needs to be harvested, packed, transported, unloaded, and, finally, displayed for sale. Depending upon the location of the marketplace, this process may also require storing the produce for periods of time while awaiting transportation, unloading, or displaying. The storage may take place in a refrigerated warehouse or storeroom. If the marketplace is distant from the field or orchard, then the transportation itself of the produce requires a relatively long period of time. Indeed, for foreign markets, it may be several weeks between harvest by a farmer and end purchase by a consumer.

[0004] It is during these periods of storage and transportation that are of primary concern for farmers and merchants. If not handled properly, produce will spoil, and profits will sag.

Accordingly, time, money, and energy are dedicated to improving the packing and the preservation of produce to maximize the quality of produce for market.

[0005] When harvested, produce is typically placed in cartons which, in turn, are stacked on pallets. This may take place in the field or orchard or in a nearby warehouse. When palletized, the cartons of produce may then be easily moved by forklift to refrigerated tractor-trailer rigs and, if needed, to refrigerated containers for loading onto trains and ships.

[0006] To enhance the preservation of produce when on a pallet, an oxygen-depleted artificial atmosphere may be created by wrapping either individual cartons of produce or an entire stack of cartons of produce in plastic film. Oxygen levels within the wrapped carton or stack of cartons may then be minimized, for example, by injecting nitrogen into or by evacuating gas from within the wrapped stack of cartons.

[0007] One example of a conventional approach to preserving produce is disclosed in United States Patent No. 5,945,147 entitled "Method for Packaging Fresh Perishable Food" by James A. Borchard (who is also the inventor in the present application), the entire disclosure of which is incorporated herein by reference.

[0008] Other conventional approaches entail covering a stack of cartons on a pallet with a bag and then sealing bottom edges of the bag to create a substantially hermetic environment. Conventional systems perform this bagging process in assembly-line fashion using a conveyor. Pallets of produce are moved on the conveyor through successive stages of placing a bag over a stack of cartons, sealing the opening of the bag with adhesive tape, and applying gas to preserve the produce within the bag. Each stage requires manual labor, thereby increasing cost. In addition, the bagging process is carried out in a refrigerated warehouse in which costs are directly proportional to the amount of floor space required for the preservation operation.

[0009] In addition to preservation, cartons of produce may also require fumigation. Conventional approaches to fumigating cartons of produce entail moving pallets of produce into large chambers, fumigating the chamber, and then removing the pallets from the chamber. Once again, large warehouse space and substantial manual labor are required.

[0010] In view of the foregoing, there remains a need in the art for systems and methodology that seal and, if desired, preserve a load, for example, a stack of cartons containing produce, placed on a pallet in an efficient and cost-effective manner.

BRIEF SUMMARY OF THE INVENTION

[0011] In view of the foregoing, the present invention presents technology in the form of apparatus, associated operative methodology, and general methodology that enables a load placed on a pallet to be sealed. In many preferred embodiments, particularly involving fresh produce, the methods and apparatus of the present invention are particularly beneficial in that produced packed in cartons that are stacked on a pallet may be sealed in the field and readied for shipping and/or storage. The present invention eliminates the need for large warehouses and manual labor.

[0012] According to a preferred embodiment, a system for sealing a load with film, where the load is placed on a pallet, includes a frame and a vertically moveable platform on which the pallet is received. A clamp is mounted to the frame and is configured to engage sides of the load when the pallet is received on the platform. A rack is mounted to the frame such that the rack is vertically movable between an upper position in which the rack is above a top of the load and a lower position in which the rack is below a bottom of the load. A pair of cross members are mounted to the rack such that the cross members are horizontally movable. The system also includes engagement subsystem and sealing subsystem mounted to the cross members. The engagement subsystem is configured to engage sides of the film, and the sealing subsystem is configured to seal the sides of the film together.

[0013] In operation, when the pallet is placed on the platform, the sides of the film, which in the form of a sleeve where the sides define an inner space when separated, are engaged with the engagement subsystem when the rack is in the upper position, for example, with vacuum ports. Thereafter, the cross members move outwardly to separate the sides of film and to define the inner space. The rack is then moved to the lower position, thereby enveloping the load within the sleeve of the film. The load is then secured with the clamp and separated from the pallet. The cross members are then moved inwardly so that the sides of the film are brought together, which are then sealed with the sealing subsystem, for example, with heat. The sides of the film are

disengaged, and the cross members are moved outwardly. The load may then be replaced on the pallet with the seal positioned therebetween. In a preferred embodiment, the film is then sealed and cut at the top of the load, thereby forming a bag around the load.

[0014] According to a preferred embodiment, the entire sealing process between initially placing the unsealed load and pallet on the platform and removed the sealed load and pallet from the platform, is substantially automated. Accordingly, a control unit may be provided along with a power supply to control and actuate each of the subsystems of the overall sealing system. Accordingly, substantial manual labor is reduced and uniformly sealed loads are provided.

[0015] According to preferred methodology of the invention, a method for sealing a load placed on a pallet includes first enveloping the load within film and then securing the load independently of the pallet. The load may then be separated from the pallet, and a seal may be formed in the film under the bottom of the load. In a preferred embodiment, the seal is in the form of a flap that is sandwiched between the bottom of the load and the pallet without any buckling so that the sealed load rests with stability on the pallet.

[0016] According to further preferred embodiments, particularly those involving fresh produce, the sealing system of the present invention may also include subsystems for evacuating the load when enveloped by the film to remove oxygen and subsystem for fumigating the load. Accordingly, a preferred artificial atmosphere may be created within the sealed film for the load, thereby retarding the ripening process of the produced and enhancing freshness during shipping and storage.

[0017] Other features and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0018] FIG. **1** is a front plan view of an exemplary system for sealing a load placed on a pallet configured in accordance with the present invention;

[0019] FIG. **2** is a side plan view of the sealing system of FIG. **1**;

[0020] FIG. **3** is a perspective view of the exemplary roll of film utilized by the methods and apparatus of the present invention, particularly illustrating film with sides that define an inner space therebetween;

[0021] FIG. **4** is a top view of the sealing system the invention, particularly illustrating cross members movably mounted on a rack;

[0022] FIG. **5** is a fragmentary perspective view of a propulsion system for a rack mounted on a frame in accordance with an exemplary embodiment of the invention;

[0023] FIG. **6** is a fragmentary cross-sectional view of the propulsion system taken along line 6—6 of FIG. **5**;

[0024] FIG. **7** is a perspective view of an exemplary embodiment of a rack and cross member system of the present invention;

[0025] FIG. **8** is a schematic view of a sealing subsystem configured according to an exemplary embodiment of the invention;

[0026] FIG. **9** is a block diagram of a sealing system according to a preferred embodiment of the invention;

[0027] FIG. **10** is a fragmentary perspective view of a cutting and a sealing subsystem configured in accordance with an exemplary embodiment of the present invention;

[0028] FIG. **11** is a fragmentary cross-sectional view of an exemplary propulsion subsystem for the cutting subsystem of FIG. **10**;

[0029] FIG. **12** is a fragmentary perspective view of a cross member on which components of a cutting subsystem and a sealing subsystem are disposed according to exemplary embodiments of each;

[0030] FIG. **13** is a fragmentary perspective view of a propulsion system for a rack mounted on a frame in accordance with another exemplary embodiment of the invention;

[0031] FIG. **14** is a perspective view of a rack and cross member system according to another embodiment of the present invention;

[0032] FIG. **15** is a perspective view of pleated film utilized by the sealing systems of the present invention;

[0033] FIG. **16** is a cross-sectional view of pleated film taken along line 16—16 of FIG. **15**;

[0034] FIG. **17** is a flowchart illustrating preferred methodology for sealing a load placed on a pallet in accordance with the present invention;

[0035] FIG. **18** is a table illustrating steps in a preferred embodiment for sealing a load on a pallet in accordance with the invention;

[0036] FIGS. **19A** through **19J** are front plan view of a load, film, and a pallet, with each figure respectively illustrating a successive step in exemplary methodology of the invention;

[0037] FIGS. **20A** and **20B** are fragmentary side plan views of a sealing subsystem including vacuum and injection subsystems of the invention, particularly illustrating the subsystems in relation to film for sealing a load;

[0038] FIG. **21** is a fragmentary perspective view of film enveloping a load in accordance with the invention, particularly illustrating a seal formed in the film at a bottom of the load;

[0039] FIG. **22** is a perspective view of pleated film enveloping a load in accordance with the invention;

[0040] FIG. **23** is a side plan view of a load being sealed within film according to the invention, particularly when the load is separated from a pallet;

[0041] FIG. **24** is a side plan view of a sealed load positioned on a pallet in accordance with the invention;

[0042] FIG. **25** is a enlarged fragmentary cross-sectional view of a flap sandwiched between a bottom of a sealed load and a pallet in accordance with an exemplary embodiment of the invention;

[0043] FIGS **26A** and **26B** are fragmentary perspective views of an enveloped load where a seal is formed by folding a flap over to one side to be compressed between the load and a pallet; and

[0044] FIGS. **27A, 27B**, and **27C** are fragmentary side plan views of a sealing subsystem including cutting and heat-sealing subsystems of the invention, particularly illustrating the subsystems in relation to film at a top of a load.

DETAILED DESCRIPTION OF THE INVENTION

[0045] Referring more particularly to the drawings, an exemplary sealing system **50** for sealing a load **52** placed on a pallet **54** and configured in accordance with the teachings of the present invention is illustrated in FIGS. **1** and **2**. For purposes of explanation and without limiting the scope of the present invention, exemplary system **50** is illustrated and described herein as a system for sealing and preserving a load **52** of produce such as fruits or vegetables packed in a plurality of cartons **56**, which cartons are stacked on the pallet **54**. However, those skilled in the art will appreciate that the principles of the present invention are equally applicable to any load which is receivable on a pallet for storage or transportation.

[0046] The present invention provides not only apparatus for sealing a load placed on a pallet but also methodology associated with utilizing the apparatus of the invention, as well as general methodology for sealing a load placed on a pallet. The description the apparatus of the invention follows hereafter, with the operational methodology being described thereafter.

Apparatus

[0047] Exemplary sealing system **50** generally includes a frame **58** with a plurality of vertical members **60** connected between a top **62** and a base **64**, thereby defining an inside **66** of the frame. The sealing system **50** may also include a dedicated power supply **68** (shown in FIG. **2**), which is preferably disposed on the base **64**. The power supply **68** may include any number of devices and systems necessary for providing power to the elements of the invention described below, for example, a compressor **70**, an electrical supply **72** such as a generator or a motor, hydraulics, and so on. In a preferred embodiment, the frame **58** is configured so that the entire system **50** is portable so that the system can be implemented in any desired location. This portable feature of the invention is particularly beneficial in fresh produce embodiments in which the sealing system **50** may be temporarily installed in a produce field or orchard.

[0048] A base subsystem **74** including a platform **76** may be disposed within the frame **58**. The load-carrying pallet **54** is receivable on the platform **76**. Preferably, the platform **76** is mounted to a vertically movable substructure **78** connected to the power supply **68** such that the platform **68** may be raised and lowered as shown by arrow A in the drawings. Exemplary substructure **78** may be configured in any manner that enables vertical movement of the platform **68**, for example, as a scissors-like structure **80** connected to a hydraulic lift **81**. In certain implementations, it may be preferably to include one or more injection nozzles **82** disposed on sides **83** of the platform **76**, which will be discussed in more detail below.

[0049] A clamping subsystem **84** including a pair of plates **86** is mounted to the frame **58** and is connected to the power supply **68**. Exemplary clamping subsystem **84** is configured so that the plates **86** are movable horizontally as shown by arrows B in FIG. **1**, for example, under power of the motor **72**. Exemplary plates **86** are vertically disposed and configured so that at least a bottom portion of the load **52** is positioned between the plates **86** when the plates are moved inwardly. In the example shown in the drawings in which the load **52** includes a stack of cartons **56**, the plates **86** are configured to clamp at least a bottom layer **88** of cartons **56**. In many implementations, the plates **86** may be configured such that a predetermined bottom portion of the load **52** is engaged, for example, about one half of the layers of cartons **56** making up the load. Accordingly, the load **52** may be retained or secured independently of the pallet **54**.

[0050] Exemplary sealing system **50** also includes a film subsystem **90** mounted to the frame **58** and connected to the power supply **68**. Although the sealing system **50** of the present invention may be configured to seal loads with any type of film, a sleeve-type film **92** as shown in FIG. **3** is preferable. More specifically, the film **92** is preferably disposed in a roll **94** that is rotatably mounted to the frame **58**. The film **92** has sides **96**, e.g., two sides, that are integral along longitudinal edges **98** and that define an inner space **100** when separated. An opening **102** is defined at a leading cut edge **104** of the film **92**. One of the advantages of employing the film **92** shown in FIG. **3** with the sealing system **50** of the invention is that the film is commercially available and, therefore, relatively inexpensive. The frame **58** may include structure to store additional rolls **94** of film **92** as shown in FIG. **1**. In addition, to facilitate the dispensing of the

film **92** or **212**, a number of rollers **105** may be disposed on the frame **58** so that the film is dispensed from above the load **52**.

[0051] With additional reference to FIG. **4**, exemplary film subsystem **90** may include a film rack **106** that is mounted to the frame **58** so that the film rack is movable vertically as shown by arrow C in FIG. **1**. Although any type of propulsion system may be used, according to a preferred embodiment, exemplary film subsystem **90** may include a rack-and-pinion propulsion subsystem **108** configured to raise and lower the film rack **106**, as shown in FIG. **5**.

[0052] For example, exemplary propulsion subsystem **108** may include a pair of gear racks **110** respectively mounted to a pair of the vertical members **60** of the frame **58** and a pair of pinions **112** mounted on opposing ends of an axle **114**. A motor **116** may drive the axle **114** with, for example, a drive train **118**. A pair of braces **120** may be provided to support the axle **114** at or near the pinions **112**, respectively. Referencing FIG. **6**, additional support may be provided by a pair of counter wheels **122** (only one is shown) respectively and rotatably mounted to the braces **120**. The counter wheels **122** roll along a side of a respective vertical member **60** that is opposite to the side of the vertical member to which the gear rack **110** is mounted. Those skilled in the art will appreciate that many alternative embodiments of the propulsion subsystem **108** are possible, one alternative of which will be described below.

[0053] With further reference to FIGS. **1**, **2**, and **4**, exemplary film subsystem **90** may also include a pair of cross members **124** that are movably mounted to the film rack **106** with, for example, wheels **126**. Accordingly, the cross members **124** are horizontally movable with respect to the load **52** as shown by arrow D in FIG. **1** and provide support for a number of preferred subsystems of the invention, which will be discussed in more detail below.

[0054] Those skilled in the art will appreciate that there may be any number of ways to propel the cross members **124** inwardly and outwardly with respect to each other. For example, with additional reference to FIG. **7**, a cross-member propulsion subsystem **128** may include two pairs of arms **130**, with each respective pair of arms being pivotally connected between the cross members **124** at or near the wheels **126** and pivotally connected to each other at a pin **132**. In addition, exemplary subsystem **128** may include a pair of supports **134** each with a vertically disposed slot **136** for respectively and slidingly receiving one of the pins **132**. A pair of

hydraulic lifts **138** may be respectively and pivotally connected between the supports **134** and one of the arms **130**. Accordingly, when actuated, the lifts **138** contact and expand as desired, thereby drawing together and expanding, respectively, the arms **130**, with the pins **132** sliding upwardly and downwardly in the slots **136** as shown by arrow E in FIG. **7**. In response to such action by exemplary propulsion subsystem **128**, the cross members **124** move inwardly and outwardly as shown by arrow D in FIG. **7**.

[0055] One of the systems supported by the cross members **124** may be a system or means for engaging the sides **96** of the film **92**. More specifically, the film subsystem **90** preferably includes a system that engages the sides **96** of the film **92** so that the sides **96** can be separated to provide access to the inner space **100** through the opening **102**. For example, with additional reference to FIG. **8**, a vacuum subsystem **140** may be mounted to the cross members **124** and configured to engage the sides **96** of the film **92**. Exemplary vacuum subsystem **140** may include a plurality of vacuum ports **142** mounted along each of the cross members **124**. With additional reference to FIG. **9**, each of the vacuum ports **142** is in communication with a vacuum source **144** so that when actuated by a control unit **146**, the ports **142** draw air as shown by arrows F in FIG. **8**. The operation of the vacuum subsystem **140** will be described in detail below.

[0056] Exemplary film subsystem **90** may also include an injection subsystem **148** including one or more injection nozzles **150** mounted to the cross members **124**, preferably at locations below that of the vacuum ports **142** as shown in FIG. **8**. Each of the injection nozzles **150** may be in communication with a source of compressed air such as the compressor **70** so that air may be injected as shown by arrows G. In addition, one or more of the injection nozzles **150** may be connected to a gas supply **152** as shown in FIG. **9** so that gas, for example, for preservation or fumigation purposes, may be ejected.

[0057] In certain implementations, it may be preferable to pivotally mount the nozzles **150** to the cross members **124**, for example, on a linkage **154** attached to the cross member **124** at a pivot **156**. Each linkage **154** may be connected to a power source such as a dual-acting cylinder **158**. Accordingly, when actuated, the dual-acting cylinders **158** pivot the linkages **154** as shown by arrows H. The operation of the injection subsystem **148** will be described in more detail below.

[0058] Referencing particularly FIGS. **8** and **10**, the film subsystem **90** of the present invention may also include a system or means for cutting the film **92** at a desired location. More specifically, a cutting subsystem **160** may be mounted to the cross members **124** for cutting the film **92**. Exemplary cutting subsystem **160** may include a knife **161** mounted on a block **162**, preferably releasably mounted to enable replacement of the knife as desired. Exemplary cutting subsystem **160** may also include a cylinder **163** disposed between a pair of braces **164** and mounted along with the braces **164** between a pair of end brackets **165** (only one of which is shown). A collar **166** is slidably mounted on the cylinder **163** and the braces **164**, with the block **162** mounted to the collar **166**.

[0059] The cutting subsystem **160** may include means for propelling the knife **161**, for example, such as a magnet **167** slidably disposed within the cylinder **163** and a pneumatic source **168** with a knife port **169** disposed at one end of the cylinder **163**. A bumper **170** may be disposed at the other end of the cylinder **163**. Alternatively, as shown in FIG. **11**, a nozzle **169** may be disposed at each end of the cylinder **163**. The pneumatic source **168** may be in communication with the compressor **70** or, alternatively, may be the compressor itself as shown in FIG. **9**.

[0060] Accordingly, when activated, pressurized air is injected from the port **169**, thereby pushing the magnet **167** toward the other end of the cylinder **163**. Through magnetic attraction, the magnet **167** pulls the collar **166** and the knife **161** to the other end of the cylinder **163** as shown by arrow I. In accordance with this exemplary embodiment, the collar **166** may be configured to have ferrous properties to enable attraction with the magnet **167**. As shown in FIG. **12**, a channel **171** may be mounted on the cross member **124** opposite that on which the cutting subsystem **160** is mounted for receiving the knife **161** when cutting the film **92**. Those skilled in the art will appreciate that the cutting subsystem **160** may be configured in any manner that enables cutting of the film. For example, the film **92** may have transverse perforations are predetermined intervals that enable detachment.

[0061] According to the present invention, exemplary film subsystem **90** may also include a system or means for sealing the sides **96** of the film **92** together, for example, at or near the opening **102**. More specifically, referencing FIGS. **8** and **12**, a sealing subsystem **172** may be

mounted to the cross members **124** and configured to fix the sides **96** of the film **92** together to form a seal. For example, the sealing subsystem **172** may include one or more heat impulse bars **174** disposed along the cross members **124**, one set of which is shown in FIG. **9**. As shown in FIG. **8**, two sets of two heat impulse bars **174** are respectively disposed on a base **176** connected to a respective pneumatic cylinder **178**. Accordingly, when actuated, the cylinders **178** move the bases **176** toward each other as shown by arrows J, thereby pressing the film **92** between the heat impulse bars **174** which, when actuated by electric current, heat up and melt the sides **96** of the film **92** together.

[0062] Although the foregoing description recites of a specific embodiment of the invention, other embodiments are also contemplated within the broad principles of the invention. For example, an alternative embodiment of an exemplary propulsion subsystem **180** for the rack **106** of the film subsystem **90** is illustrated in FIG. **13**. This alternative propulsion subsystem **180** may include a pair of hydraulic cylinders **182** (only one is shown in the drawings) mounted to the frame **58**, for example, each with a base **184** attached to a vertical member **60** on which the gear racks **110** are mounted. A pulley system **186** may be employed to link a piston **188** of each cylinder **182** to the brace **120** mounted to the rack **106**. The pulley system **186** may include a first pulley **190** mounted to the top **62** of the frame **58** and a second pulley **192** mounted to an end of the piston **188**. A flexible member **194** may then be connected between the top **62** of the frame **58** and the brace **120** of the rack **106** via the pulleys **188** and **190**. Accordingly, when actuated, the cylinders **182** selectively extend and move the piston **188** outwardly, thereby lowering the rack **106**, and contract and move the piston inwardly, thereby raising the rack, as respectively shown by arrows K and C in FIG. **13**.

[0063] Another example of an alternative embodiment of one of the subsystems described above is illustrated in FIG. **14**, specifically, an alternative embodiment of a cross-member propulsion subsystem **196** is shown. Exemplary subsystem **196** may include two pairs of arms **198**, with each respective pair of arms pivotally connected between the cross members **124** at or near the wheels **126** and pivotally connected to a respective support **200** mounted to the rack **106** at a pin **202**. A pair of hydraulic cylinders **204** may be respectively and pivotally connected between ends of a respective pair of arms **198**. Accordingly, when actuated, the cylinders **204**

selectively contact and expand, thereby pivoting the arms **198** about the pins **202** as shown by arrows L. In response to such action by exemplary propulsion subsystem **128**, the cross members **124** move inwardly and outwardly as shown by arrow D.

[0064] With continued reference to FIG. **14**, exemplary sealing subsystem **90** may include additional apparatus for facilitating and improving the operation of the various operations thereof. For example, one or more center nozzles **206** mounted to one of the cross members **124** and in pneumatic communication with the compressor **70** as shown in FIG. **9**. Accordingly, when actuated, the center nozzles **206** eject air inwardly toward the opposing cross member as shown by arrow M in FIG. **14**. As will be described in detail below, the center nozzles **206** facilitate the formation of a preferred seal of the film **92**.

[0065] Also illustrated in FIG. **14** is apparatus that is configured to further facilitate the formation of a preferred seal of the film **92**, namely, a pair of side nozzles **208** disposed on opposing sides of the rack **106**, for example, sides **210**. As shown, sides **210** are disposed substantially perpendicular to the cross members **124**. The size nozzles **208** are in pneumatic communication with the compressor **70** as shown in FIG. **9** so that when actuated, air is ejected out of the nozzles **208** as shown by arrows N in FIG. **14**.

[0066] As will be described operationally below, the side nozzles **208** may be particularly useful in implementations utilizing a type of commercially available pleated film **212** shown in FIGS. **15** and **16**. Elements of exemplary film **212** that are substantially analogous to those of film **92** shown in FIG. **3** will be indicated with like reference numerals. Exemplary film **212** may be disposed in a roll **94** that is rotatably mountable to the frame **58**. The film **212** has a pair of sides **96** disposed between a pair of pleats **214** each having a pair of panels **216** connected along a longitudinal crease **218**. An inner space **100** is defined when the sides **96** are separated, and an opening **102** is defined at a leading cut edge **104** of the film **212**.

[0067] Operational details and additional structure elements of exemplary sealing system **50** will be expanded upon below.

Methodology

[0068] With the foregoing description focussing on the apparatus of the invention, methodology of the invention will now follow utilizing the pleated film **212** shown in FIG. **15** and **16** and referencing FIGS. **17**, **18**, and **19**.

[0069] As mentioned above, exemplary sealing system **50** seals a load **52** placed or positioned on a pallet **54**, with the sealed load then being ready to be prepared for shipping or storage. In operation, the pallet **54** with the load **52** is initially positioned on the platform **76** (step **S50**), as shown in FIG. **17A**. The film **92** may then be engaged (step **S52**) with the vacuum subsystem **140**. As described briefly above, to engage the film **92**, the cross members **124** close as indicated by Step 1 in the table of FIG. **15** and as shown by arrow D in FIG. **19A**, at which time the vacuum subsystem **140** is ON so that negative pressure, or vacuum, is created at the vacuum ports **142**. When the cross members **124** have closed a sufficient distance, the sides **96** of the film **212** are engaged and retained by the vacuum ports **142** as shown in FIG. **19B**. The load **52** may now be enveloped with the film **212** (step **S54**).

[0070] To do so, the cross members **124** may be opened as indicated by arrows D in FIG. **19B** and Step 2 in the table of FIG. **18**. The outward movement of the cross members **124** separates the sides **96** of the film **212** and enlarges the opening **102**, thereby defining the inner space **100** of the film **212** as shown in FIG. **19C**. When the cross members **124** have moved outwardly to a position beyond the width (and/or the depth) of the load **52**, the rack propulsion subsystem **180** may then be actuated to lower the rack **106** and, accordingly, the cross members **124** and the film **212** downwardly over the load **52** as shown by arrows C in FIG. **19C** and indicated by Step 3 in FIG. **18**.

[0071] To further define and to enlarge the inner space **100**, the injection subsystem **148** may be activated to inject air through the opening **102** of the film **212** either prior to and/or during the decent of the cross members **124**. For example, as shown in the exemplary embodiment of pivotal injections nozzles **150** mentioned above and shown in FIGS. **8** and **20A**, cylinders **158** may be activated to pivot the nozzles **150** inwardly as shown by arrows H in FIG. **20A**. Resulting from the rotation, a pad **220** mounted on each linkage **154** contacts an inside surface **222** of a respective one of the sides **96** of the film **92** (or **212**) and presses the side **96** against a

respective one of the cross members **124**, as shown in FIG. **20B**. In turn, the nozzles **150** may be activated to inject air upwardly through the opening **102** to expand the film **92** and enlarge the inner space **100** as shown by arrows G. Both of these preferred functions of the invention are indicated in Step 2 of the table in FIG. **18**, with the position of the injection nozzles IN and the air (e.g., from the compressor **70**) ON.

[0072] An alternative embodiment for enhancing the separation of the sides **96** and the definition of the inner space **100** of the film **212** is shown in FIG. **19D**. In this embodiment, the injection nozzles **150** as disposed on the cross members **124** in a nonrotatable manner but with the nozzles **150** directed upwardly and inwardly. Accordingly, when activated, the nozzles **150** inject air upwardly through the opening **102** as shown by arrows G to expand the film **212** and enlarge the inner space **100**. Accordingly, as the rack **106** (not shown) and the cross members **124** lower as shown by arrows C, thereby drawing additional film **212** from the roll **94** (see FIGS. **1** and **15**), the air from the injection nozzles **150** continuously expands the film **212** to prevent the sides **96** of the film **96** from catching or snagging on the load **52**, particularly at a top **224** thereof.

[0073] To further enhance this anti-snagging feature of the invention, the platform nozzles **82** may be activated to inject air upwardly as shown by arrows O. Accordingly, a barrier of positive pressurize air is defined between the load **52** and the inside surface **222** of the sides **96** of the film **212** as the cross members **124** descend, which positive air barrier is indicated by reference numeral **226** in FIG. **19E**.

[0074] When the rack **106** has reached a lower position, for example, when the cross members **124** are at a vertical position below a bottom **228** of the load **52** as shown in FIG. **19E**, then the load **52** may be secured (step **S56**), preferably independently of the pallet **54**. To do so, the clamping subsystem **84** may be activated to press the load **52** between the plates **86** as discussed above (Step 4). The injection nozzles **150** may be turned OFF at this time if desired. Once secured, the load **52** is separated from the pallet **54** (step **S58**) by, for example, lowering the platform **76** with the substructure **78** (Step 5) as shown by arrows A in FIG. **19E**; accordingly, the pallet **54** is lowered away from the load **52** as shown in FIG. **19F**. Alternatively, the clamping subsystem **84** may be configured to lift the load **52** upwardly from and off the pallet **54**.

[0075] In certain implementations, it may be desired to configured the injection nozzles **150** in communication with the vacuum source **144** so that the injection nozzles **150** may be activated to evacuate the load **52** within the film **212** (step **S60**), thereby drawing the film **92** against the load **52**. After a predetermined amount of time (e.g., **20** seconds), the vacuum at the nozzles **150** may be turned OFF (Step 6.1).

[0076] In applications of the principles of the invention involving produce, it may be preferable to fumigate the load **52** with a gas. More specifically, gas from the gas supply **152** may be provided to the injection nozzles **150** to fumigate the load **52** (step **S62** and Step 6.2). After a predetermined amount of time, the nozzles **150** may be turned OFF (Step 6.3) and, if configured according to the embodiment shown in FIG. **8**, rotated outwardly (Step 6.4) on the linkages **154**. In addition to the injection nozzles **150**, the platform nozzles **82** may also be connected to the gas supply **152** and/or the vacuum source **144**.

[0077] Once the pallet **54** is separated from the load **52** and once any optional evacuation and/or fumigation of the load **52** is completed, the film **212** may be sealed at the bottom **228** of the load **52** (step **S64** and Step 6.5). To do so, the cross members **124** may be moved inwardly (Step 6) as shown by arrows D in FIG. **19F** and brought together, thereby clamping the film **212** therebetween.

[0078] As described above, cylinders **178** may then be activated to drive the heat impulse bars **174** together as shown by arrows J in FIG. **19F**, and the heat impulse bars **174** may be activated to melt the sides **96** of the film together **92**. As shown in FIG. **21**, by heating and melting the sides **96** of the film **212** together between the heat impulse bars **174**, one or more seals **230** are formed at or near the leading cut edge **104** of the film **212**.

[0079] The formation of the seal **230** may be enhanced by utilizing the side air nozzles **208**. More specifically, as shown in Step 6 of FIG. **18**, when the cross members **124** close, the side air nozzles **208** may be actuated to inject air toward the pleat **214** of the film **212** (see FIGS. **14** and **15**) as shown by arrows N in FIGS. **22** and **23**, thereby urging the crease **218** inwardly. The inward movement of the crease **218**, in turn, causes the panels **216** to neatly fold and substantially align when the heat seal bars **174** are brought together to form the seal(s) **230**, thereby forming a flap **232** without substantial buckling of the film **212** as shown in FIG. **21**.

[0080] After a predetermined amount of time sufficient to form an adequate seal **230**, the cross members **124** may open (Step 7) as shown by arrows D in FIG. **19G**, and the load **52** may be replaced on the pallet **54** (step **S66**). According to the preferred embodiment shown in the drawings, this step may be carried out by raising the platform **76** (Step 8) until the load **52** rests thereon.

[0081] To enhance the placement of the load **52** on the pallet **54**, the flap **232** may be folded over to one side or the other as shown in FIG. **19G**. For example, the center air nozzle **206** may be activated as shown in Steps 7 and 8 in FIG. **18** to blow air inwardly toward the flap **232** as shown by arrow M in FIG. **19G**, thereby urging the flap **232** to fold upwardly as shown by arrow P. The platform **76** may then be raised as shown by arrow A, with the flap **232** neatly folded over and positioned between the pallet **54** and the bottom **228** of the load **52** as shown in FIGS. **19H**, **24**, and **25**. In other words, the flap **232** is preferably sandwiched in a planar relationship between the bottom **228** of the load **52** and the pallet **54**. Accordingly, the load **52** rests with more stability than may be possible otherwise.

[0082] In an alternative embodiment shown in FIGS. **26A** and **26B**, a seal may be formed without utilizing the heat impulse bars **174**. More specifically, by folding of the flap **232** and positioning the flap **232** between the pallet **54** and the bottom **228** of the load **52**, a seal **234** along a fold line **236** of the flap. When the load **52** is replaced on the pallet **54**, the weight of the load **52** presses the sides **96** of the film **212** together, particularly along the fold line **236**, to maintain the seal **234**.

[0083] The pallet **54** on which the load **52** is positioned after the seal is formed may be the same pallet on which the load **52** was originally positioned within the frame **58** or may be another pallet as desired by the user. More specifically, in certain embodiments, it may be preferable to replace the originally used pallet **54** (e.g., as shown in FIG. **19A**) with another pallet **54**, either of different dimensions or made of different material.

[0084] Once replaced on a pallet, the load **52** may be released by the clamping subsystem **84** (Step 9), and the rack **106** and, accordingly, the cross members **124** may be raised as shown by arrows C in FIG. **19H**. The rack **106** may be raised to an upper position, for example, where the

cross members **124** are at a vertical position above the top **224** of the load **52** (Step 10) as shown in FIG. **19I**.

[0085] The film **212** may now be cut and sealed at the top **224** of the load **52** (step **S68**). To carry out this operation, the cross members **124** may be moved inwardly as shown by arrows D in FIG. **19I** and **27A** and closed (Step 11) as shown in FIGS. **19I** and **27B**. Analogous the description above, the side air nozzles **208** may again be actuated to enhance the formation of the pleat **214** in the film **212** at the top **224** of the load **52**. As shown FIG. **27**, the cross members **124** may include one or more bumpers **238** disposed at various longitudinal locations thereof. The bumpers **238** are configured so that the film **212** is pressed between opposing pairs of bumpers **238** and held in place, as particularly shown in FIG. **27B**.

[0086] When in this position, the cutting subsystem **160** may be activated to cut the film **212** with the knife **161**. For example, the knife **161** may pierce the film **212** as shown in FIG. **19I** and **27B**, and the pneumatic source **168** (see FIG. **10**) may be actuated to urge the knife **161** transversely through the film **212**. Thereafter, the sealing subsystem **172** may be activated to form a seal in the film **212** analogous to that described above (Step 11.1).

[0087] When the film **212** has been cut and sealed at the top **224** of the load **52**, the cross members **124** may be moved outwardly as shown by arrows D in FIG. **27C** (Step 12). A seal (which is indicated by reference numeral **240**) is, accordingly, formed in the film **212** at or near a trailing cut edge **242** of the film **212**. The rack **106** may now be raised (Step 13) to an original starting position above the load **52** as shown by arrow C in FIG. **19J**, and the load **52**, now sealed, may be removed from the frame **58** on the pallet **54** (step **S70**). If desired, another load placed on a pallet may be positioned on the platform **76**, and the process repeated (step **S70** and Step 14). As shown in FIG. **19J**, when a load **52** is sealed on a pallet **54** in accordance with the methodology of the invention, the film **212** (or **92**) forms a bag **244** around the load **52**, with a seal **230** or **234** formed under the bottom **228** of the load and a seal **240** formed over the top **224** of the load.

[0088] Referencing FIG. **25**, in implementing of the principles of the present invention in the context of preservation of produce, it may be preferable to seal the load **52** such that a preferred artificial environment is create within the sealed film **212**. For example, if the load **52** comprises

strawberries packed in cartons **56**, then during the fumigation step (step **S62**), nitrogen may be ejected from the injection nozzles **150** (and/or the platform nozzles **82**). When the film **212** is sealed, an internal pressure P_i within the film **212** is created. According to a preferred produce embodiment, the internal pressure P_i is greater than an ambient pressure P_a outside of the film **212**. The artificial atmosphere and the pressure difference retards the ripening of the produce packed within the cartons **56** by minimizing the amount of oxygen within the film **212** and inhibiting any respiration of oxygen through the film **212**.

[0089] Those skilled in the art will understand that the preceding exemplary embodiments of the present invention provide the foundation for numerous alternatives and modifications thereto. These other modifications are also within the scope of the present invention. Thus, by way of example, but not of limitation, the frame **58** of the present invention may be configured to be portable so that, for example, a forklift can load and move the system **50** relatively easily, thereby increasing the functionality of the system. In addition, the load does not need to be placed on a pallet but may be set directly on the platform. Accordingly, the present invention is not limited to that precisely as shown and described in the present invention.